

EXTENDED CAPACITANCE RANGE MEASUREMENTS

WITH THE

33 SERIES RF ADMITTANCE BRIDGES

33/11B/12B

c-772

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SECTION I

GENERAL DESCRIPTION

The Model 33 series RF Admittance Bridges measure capacitance by the substitution method. Measurements beyond the basic 150 pF range, therefore, may be made by employing (1) external capacitors which may be placed in parallel with the variable, internal, calibrated capacitor, and (2) associated work coils which will resonate with the resultant capacitance so that the bridge may be balanced.. The external capacitors must have high Q, low inductance, stability, and repeatability when connected to the test terminals of the 33B. The work coils must have a Q great enough so that initial balance of the 33B can be established within the range of the G ZERO control. Model 33-11B Extended Range Capacitors and Model 33-12B Extended Range Work Coils have been designed for this purpose. When ordering, specify model number, capacitance range, and frequency. See Table I for the available combinations.

To make an extended range measurement, it is necessary to know the capacitance and conductance of the Extended Range Capacitor. A single capacitance calibration holds for all frequencies involved, but a separate conductance calibration is required for each frequency of interest. Given these parameters, the 33 may now be set up to read conductance directly and capacitance in terms of the dial reading plus a fixed quantity. See Section II for the accuracy of the extended range measurements.

SECTION II
SPECIFICATIONS

CAPACITANCE RANGE	See TABLE I
CONDUCTANCE RANGE	0 to 25000 micromhos
CAPACITANCE ACCURACY	$\pm(2\% + \frac{0.4}{L}\%)$
CONDUCTANCE ACCURACY	$\pm(2\% + \frac{Qf}{500}\% + 3 \mu\text{mhos})$

where,

L = resonating inductance of
test capacitance, μH

f = test frequency, Mc/s

Q = Q of test specimen = $\omega C/g$

and

ωC = susceptance of test
specimen, mhos

g = conductance of test
specimen, mhos

SECTION II-A

WORK COIL SET-UP PROCEDURE

Before measurements can be made as described in SECTION III, each of the work coils must be adjusted as follows:

1. Perform the warm-up procedure as described in Paragraph 3.1.1.
2. Select a work coil and associated capacitor.
Refer to TABLE I for the proper combination.
3. Install the work coil and capacitor as described in Paragraph 3.1.3.
4. Set the CAPACITANCE and CONDUCTANCE dials as specified in TABLE I under "For Initial Balance".
5. Set the C ZERO control to the approximate center of its range. (5 1/2 turns from either stop.)
6. Alternately adjust the work coil slug and the G ZERO control for the best balance obtainable. (10 to 12 divisions indicated on the Null Meter is satisfactory.)

The work coil is now properly adjusted.

SECTION III

OPERATING PROCEDURE

NOTE: In order to eliminate the necessity of referring to various sections of the 33A Instruction Manual, this operating procedure is complete for making extended range measurements.

3.1 INITIAL SET-UP

- 3.1.1 Connect the power cable to an a-c outlet of 105 to 125 volts, 50/60 Hz. Turn the instrument on and allow a warm-up period of at least one hour. In order to minimize drift, remove the Extended Range Work Coils and the Extended Range Capacitors from their case and place them atop the instrument for temperature stabilization during the warm-up period.
- 3.1.2 Switch the DC BIAS control to the OFF position and turn the RF LEVEL and SENSITIVITY controls to mid-position. Set FREQUENCY-MC dial to desired test frequency.
- 3.1.3 Insert one of the work coils in the three terminal receptacle on top of the instrument and tighten the set screws to insure stable contact conditions. Install the appropriate Extended Range Capacitor on the binding posts and tighten the knurled nuts securely. See Table I for the selection of the proper work coil and capacitor.

IMPORTANT: The binding post contact surfaces (both nut and thumbscrew) must be clean to insure an accurate measurement. Any accumulation of foreign matter on the gold plating will introduce a variable series loss resulting in an error which becomes greater with increasing capacitance.

TABLE I

FREQ.	CAPACITANCE RANGE	USE WORK COIL	ADD EXTENDED RANGE CAP	FOR INITIAL BAL.		C _e
				SET "C" DIAL TO	SET "G" DIAL TO	
1 Mc/s	150 - 300 pF	1A	C _____	_____	_____	+150
1 Mc/s	300 - 450 pF	1B	C _____	_____	_____	+300
1 Mc/s	450 - 600 pF	1C	C _____	_____	_____	+450
1 Mc/s	600 - 750 pF	1D	C _____	_____	_____	+600
1 Mc/s	750 - 900 pF	1E	C _____	_____	_____	+750
1 Mc/s	900 - 1050 pF	1F	C _____	_____	_____	+900
*1 Mc/s	1050 - 1200 pF	1G	C _____	_____	_____	+1050
*1 Mc/s	1200 - 1350 pF	1H	C _____	_____	_____	+1200
*1 Mc/s	1350 - 1500 pF	1J	C _____	_____	_____	+1350

5 Mc/s	150 - 300 pF	2A	C _____	_____	_____	+150
5 Mc/s	300 - 450 pF	2B	C _____	_____	_____	+300
5 Mc/s	450 - 600 pF	2C	C _____	_____	_____	+450
5 Mc/s	600 - 750 pF	2D	C _____	_____	_____	+600
5 Mc/s	750 - 900 pF	2E	C _____	_____	_____	+750
5 Mc/s	900 - 1050 pF	2F	C _____	_____	_____	+900
*5 Mc/s	1050 - 1200 pF	2G	C _____	_____	_____	+1050
*5 Mc/s	1200 - 1350 pF	2H	C _____	_____	_____	+1200
*5 Mc/s	1350 - 1500 pF	2J	C _____	_____	_____	+1350

*Available on special order only.

TABLE I (cont'd)

FREQ.	CAPACITANCE RANGE	USE WORK COIL	ADD EXTENDED RANGE CAP	FOR INITIAL BAL.		C _e
				SET "C" DIAL TO	SET "G" DIAL TO	
10 Mc/s	150 - 300 pF	3A	C _____	_____	_____	+150
10 Mc/s	300 - 450 pF	3B	C _____	_____	_____	+300
10 Mc/s	450 - 600 pF	3C	C _____	_____	_____	+450
10 Mc/s	600 - 750 pF	3D	C _____	_____	_____	+600
10 Mc/s	750 - 900 pF	3E	C _____	_____	_____	+750
10 Mc/s	900 - 1050 pF	3F	C _____	_____	_____	+900
*10 Mc/s	1050 - 1200 pF	3G	C _____	_____	_____	+1050
*10 Mc/s	1200 - 1350 pF	3H	C _____	_____	_____	+1200
*10 Mc/s	1350 - 1500 pF	3J	C _____	_____	_____	+1350
20 Mc/s	150 - 300 pF	4A	C _____	_____	_____	+150
20 Mc/s	300 - 450 pF	4B	C _____	_____	_____	+300
20 Mc/s	450 - 600 pF	4C	C _____	_____	_____	+450
30 Mc/s	150 - 300 pF	5A	C _____	_____	_____	+150

*Available on special order only.

- 3.1.4 The CAPACITANCE and CONDUCTANCE dial settings for initial balance, as given in Table I, depend upon the frequency, work coil, and capacitance range. Set the CAPACITANCE and CONDUCTANCE dials according to TABLE I and adjust the ZERO controls so that the null indicator deflection is at minimum.

3.2 MEASUREMENT

- 3.2.1 Remove the Extended Range Capacitor and connect the test specimen to the test terminals on top of the instrument. Lead lengths must be kept to absolute minimum - less than 1/8 inch for best accuracy. The binding post on the right is at ground potential. The left post is above ground and may be biased by either the internal or an external power supply.
- 3.2.2 If internal d-c bias is desired, the voltage applied to the test may be measured by connecting an appropriate d-c voltmeter (ungrounded) to the METER terminals. The sensitivity of the meter should be at least 20,000 ohms/volt. Removal of the meter will cause the bias voltage to rise because of the high output resistance (approx. 15 K) of the supply. Therefore, the internal d-c supply is a voltage source with the short circuit current limited to 6 ma. External bias to ± 250 volts may be applied through front panel terminals but must be externally monitored. The short circuit current in this case will be limited by the resistance of the internal wiring (approx. 0.7 ohms) and the resistance of the Work Coil in use.

WARNING: With the BIAS switch in the EXTERNAL position, never apply an instantaneous voltage of more than 100 V.D.C. to the EXTERNAL binding posts unless a protective resistor ($R=10 \times$ bias voltage) is inserted in series with the hot lead. Resistive protection is recommended whenever the measurement will allow. To apply external bias of between 100 and 250 V.D.C. without resistive protection, use an adjustable power supply and set the voltage to the desired level after connection to the 33 EXTERNAL binding posts. Always adjust the external power supply for less than 100 V.D.C. before throwing the D.C. BIAS switch to or from the EXTERNAL position. Never short the HI and GND

binding posts (top of instrument). Damage to the bridge section components will result when (1) the protective resistor is used but the voltage is greater than 100 V.D.C., (2) the protective resistor is not used and the current exceeds 200 milliamperes.

- 3.2.3 The RF LEVEL control provided on the front panel may be adjusted for specified r-f test level. The test voltage must be measured across the test terminals with a suitable r-f millivoltmeter (i.e., BEC 92A RF Voltmeter). The voltage should be measured after the bridge is balanced with the test specimen and the r-f voltmeter connected. This same voltage will appear across the test specimen upon rebalancing the bridge with the voltmeter removed. The minimum RF level varies from approximately 5 mV at 100 MHz to less than 1 mV at 1 MHz. To further decrease the test voltage, a 50 ohm pad may be inserted at the BNC connector of the bridge transformer lead.
- 3.2.4 With the test specimen connected, alternately adjust the CAPACITANCE dial and the CONDUCTANCE dial for minimum null indicator deflection.
- 3.2.5 The capacitance of the test specimen is:

$$C_p = C_d + C_e$$

where

C_d = final setting of CAPACITANCE dial for bridge balance with unknown connected.

C_e = from Table I

- 3.2.6 The conductance of the specimen is:

$$G_p = G_d + G_c$$

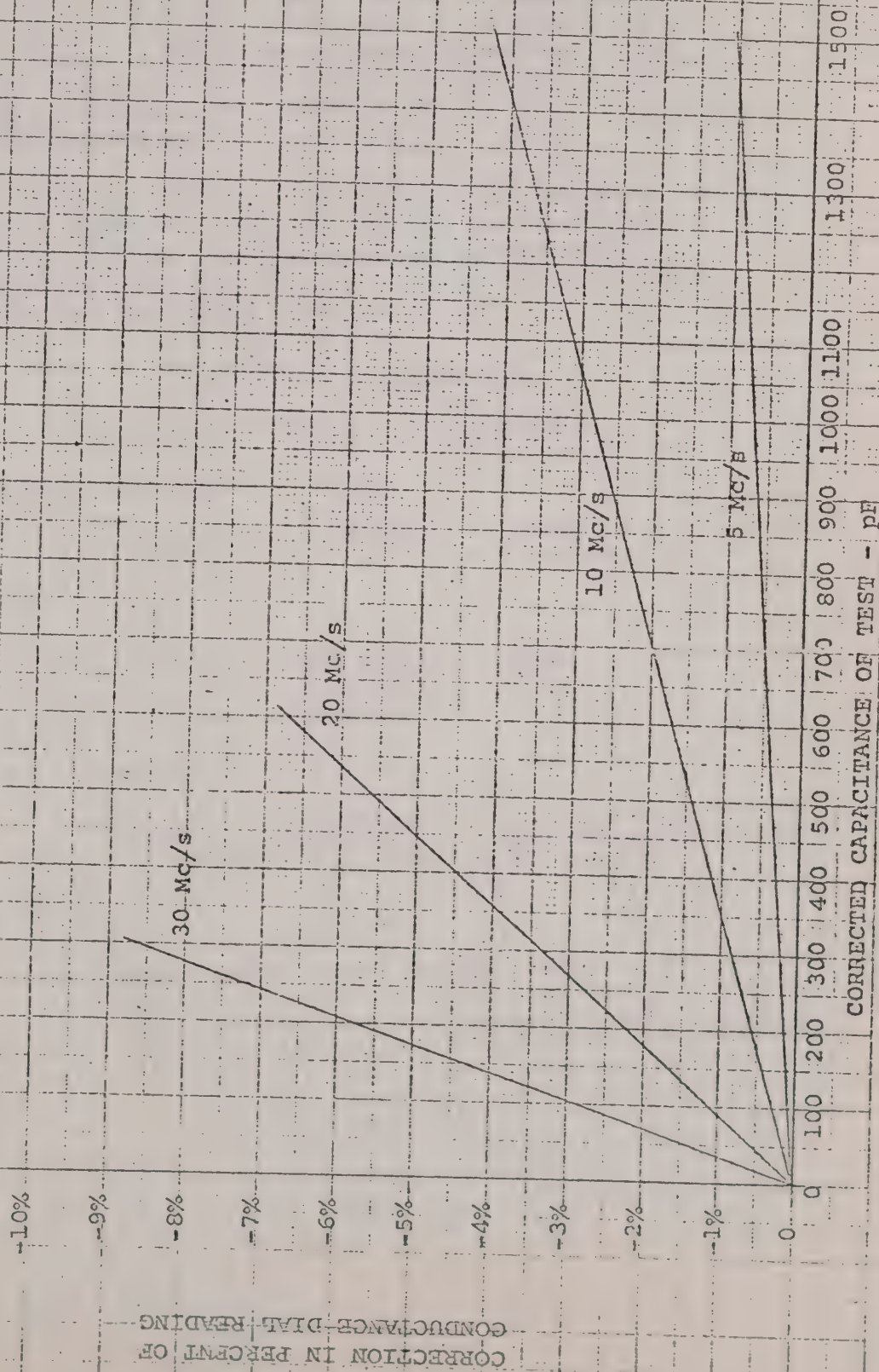
where

G_d = final setting of the CONDUCTANCE dial for bridge balance with the unknown connected.

G_c = correction applied to G_d . Calculated from Figure 1.

MODEL 33A RF ADMITTANCE BRIDGE

CONDUCTANCE CORRECTION CURVES



3.3 EXAMPLE MEASUREMENT

3.3.1 A capacitor of approximately 380 pF is to be measured at 10 Mc/s. Refer to TABLE I to establish the initial balance conditions. Work Coil 3B and Extended Range Capacitor C 380 are required. The CAPACITANCE dial is set to 79.5 pF, since the actual value is 379.5, and the CONDUCTANCE dial is set to 13.3 μhos.

With the bridge balanced, remove the Extended Range Capacitor and connect the unknown to the HI and GND binding posts using the shortest possible lead lengths. The bridge now balances with the following readings:

$$\text{Capacitance} = \underline{82.13} \text{ pF}$$

$$\text{Conductance} = \underline{17.4} \text{ μhos}$$

From the equation of 3.2.5:

$$C_p = \underline{300} + \underline{82.13} = \underline{382.13} \text{ or } \underline{382.1} \text{ pF}$$

where

$$C_d = \underline{82.13} \text{ pF (final balance value)}$$

$$C_e = \underline{300} \text{ pF (from TABLE I)}$$

From the equation of 3.2.6:

$$G_p = \underline{17.4} + (\underline{-0.209}) = \underline{17.191} \text{ or } \underline{17.2} \text{ μhos}$$

(resolution of dial at this point)

where

$$G_d = \underline{17.4} \text{ μhos (final balance value)}$$

$$G_c = \underline{-1.2} \% \text{ of } \underline{17.4} = \underline{-0.209} \text{ μhos (from FIGURE 1)}$$

CALIBRATION CERTIFICATE

FOR

EXTENDED RANGE CAPACITORS

MODEL 33-11A

Calibration for use with Boonton Electronics Corporation
Model 33A RF Admittance Bridge

S/N	Nominal VALUE	Actual VALUE	CONDUCTANCE				
			1 MHz	5 MHz	10 MHz	20 MHz	30 MHz
230.3	230 pF	230.6	_____ μS	_____ μS	_____ μS	_____ μS	77 μS
230.3	230 pF	230.4	_____ μS	_____ μS	_____ μS	33 μS	
380.1	380 pF	378.8	_____ μS	_____ μS	_____ μS	55 μS	
532.0	532 pF	530.6	_____ μS	_____ μS	_____ μS	140 μS	
380.1	380 pF	379.5	_____ μS	_____ μS	13.3 μS		
532.0	532 pF	532.0	_____ μS	_____ μS	33 μS		
678.2	678 pF	675.0	_____ μS	_____ μS	37 μS		
828.2	828 pF	829.1	_____ μS	_____ μS	70 μS		
976.6	976 pF	975.9	_____ μS	_____ μS	97 μS		

All capacitors calibrated at 25°C.

Calibration is valid only when the capacitor is properly connected (large tab to GND post) to the unmodified binding posts of a Model 33A RF Admittance Bridge. All contact surfaces (binding posts, 33-11A tabs, and leads of unknown) must be clean in order to assure repeatable results.

Calibrated S. Fischer

Approved W. Delaney J.P.H.

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